

Report on an Epidemic of Typhoid Fever in Forestville.

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About the middle of April word was received at the office of the State Board of Health from Dr. H. D. Brennan, the Health Officer of Bristol, that there was a considerable outbreak of typhoid fever in Forestville. By direction of Dr. C. A. Lindsley, the Secretary of the State Board of Health, I visited Forestville on April 28th, for the purpose of making an inquiry concerning the nature and extent of the outbreak and the source of the infection. My investigations begun on that day were continued at a subsequent visit, and by conferences and correspondence with Dr. H. D. Brennan, the Health Officer, with Dr. Charles M. Kent of Forestville, and with several physicians residing in Bristol and Plainville, who had seen cases occurring in Forestville. My thanks are due to all of these gentlemen for the courtesy of their prompt assistance.

Forestville is a village of about 1,500 inhabitants, located in the town of Bristol, fifteen miles west of Hartford on the Highland division of the New York, New Haven and Hartford Railroad. It is in a farming district, but the village contains some factories, the chief of which is the burner factory of the Bristol Clock and Brass Co. The village is not supplied with water from the Bristol water works, but has a small local system owned by private parties which will be more fully described later. There is no sewage system; the use of cesspools and privies being the common method of sewage disposal.

In order to obtain information concerning the cases of typhoid fever which had occurred in Forestville, letters of inquiry, with the necessary blanks, were sent to the physicians practicing in the village. The data of cases given below are all derived from these reports.

Previous to the outbreak in March there had been no recognized cases of typhoid fever in Forestville during the year, and

the last case known began October 27, 1899, and was located on Frederick street. The total number of cases of which reports were received as having occurred in Forestville during the two months ending May 2d was 46. There were two other cases, one in Plainville and one in Bristol, which obviously belong to the same group, and are therefore included in the following statement of statistics. Of the 48 cases, 25 were males and 23 were females. The ages are shown in the following table:

Under 5 yrs.	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Over 50
4	9	5	2	12	3	5	2	3	2	1

The dates when the cases were taken ill were reported to be as follows:

Date, Mar. 23,	24,	25,	26,	27,	28,	29,	30,	31.	April 1,	2,	3,	4,			
Cases.....	4	1	1	—	1	—	1	—	5	1	1	2			
Date, April 5,	6,	7,	8,	9,	10,	11,	12,	13,	14,	15,	16,	17,	18,	19,	
Cases	3	2	3	4	1	1	1	3	1	—	2	—	—	1	1
Date, April 20,	21,	22,	23,	24,	25,	26,	27,	28,	29,	30.	May 1,	2.			
Cases	2,	1	1	1	—	1	—	—	—	—	1	1			

THE NATURE OF THE ILLNESS.

In regard to many of the cases there was no doubt as to the diagnosis in the minds of the attending physicians, as their typhoid character was well defined. As is usual in typhoid epidemics, however, there was a considerable number of mild cases concerning the nature of which there might well have been doubt except for the connection with other cases of better defined characteristics. Certain physicians did express doubt as to the correctness of the diagnosis, especially during the early part of the epidemic, and there was much uncertainty on the part of the public.

At the time of my first visit samples of blood were taken from three selected cases with the object of applying the Widal test. The first case was that of a lad of 11 years, who was in the twenty-eighth day of his illness, the typhoid nature of which there appeared to be no doubt. The second case was a young lady of 20 years, who had been ill thirteen days with a mild febrile attack. The third case had been under the observation of a physician for eight days, and was believed to be suffering from a malarial fever. The three samples of blood were

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examined by Prof. C. J. Bartlett in the Baeteriological Laboratory of the Yale Medical School, and he reported that all of them gave positive reactions with the Widal typhoid test. This result confirmed the diagnosis of typhoid fever and indicated that the mild cases were of the same nature as the well-marked ones. The general serious character of the cases is indicated by the comparatively high mortality; there having been seven deaths at the time of writing.

THE MEANS OF INFECTION.

It is a well recognized principle in seeking the cause of an outbreak of typhoid fever affecting a considerable number of persons, to look for it in connection with the food supply. Addressing myself to this problem, it was quickly ascertained that the persons affected in the Forestville outbreak were not so connected socially that they could have been infected at any public gathering, as might have happened through the agency of infected ice cream or oysters at a dinner. There had been no such gathering, furthermore the dates on which the cases occurred did not indicate an infection occurring on a single occasion, but rather that the period of infection had extended over many days. Neither was there any common place where infection might have occurred such as might result from employment of all the persons affected in one factory. Therefore, the cause was to be sought in some common means of infection which might reach a large number of persons in their homes or boarding places. Of such means, the ice, milk and water supplies especially call for investigation.

The Ice Supply.

The ice supply of Forestville is furnished by one dealer and is derived from a pond situated near the village. It was quickly eliminated as a possible source of the infection, as immediately preceding the outbreak and during the first part of it no ice was furnished for family use, the trade not usually beginning until the first of May.

The Milk Supply.

There were two regular dealers who furnished milk to customers by delivery wagons. They supplied most of the milk

sold in the village, but there were several other persons who supplied special customers and persons in their neighborhood.

Of the 48 cases of typhoid fever, 22 were supplied by one of the regular dealers, 8 by the other, and 8 were in families supplied by both dealers. Of the remaining 10 cases, 4 obtained their milk from one source and the others from six different sources. It therefore appears that 22 of the cases obtained milk wholly from one dealer, and that 8 others derived part of their supply from him, and hence that 30 cases may have used milk from this source, but that 18 others did not have any connection with it.

Because of the large number of cases connected with this supply the following details concerning it are given. The dairy is located in Forestville and the milk route in the village includes 60 families. About three times as much milk was sold to customers in Bristol, three miles distant, as in Forestville. The milk was derived from four sources; that from one source was sold chiefly in Bristol. The milk from the other three sources was all mixed in a tank at the dairy before distribution. Of this mixed milk, one-fourth was used in Forestville and the rest in Bristol. During the prevalence of the epidemic in Forestville, there were very few cases in Bristol. Two cases, however, were reported to me by physicians as having occurred among the customers of the dairy in question. That the milk was the source of the infection of these two cases occurring among several hundred customers, is doubtful. The facts presented show conclusively that the common means of infection in Forestville was not in any of the milk supplies.

The Water Supply.

The village is supplied with water from numerous wells, none of which are used in common by a large number of persons, and from the pipes of a small local water system which has been operated by a private company for about twelve years. The water furnished by the company is drawn from a spring situated in the western part of the village near the corner of Stafford avenue and Brook street. The water is pumped from the spring directly into the distributing pipes, but the pipes are so arranged that any excess of water pumped is forced back into a reservoir situated west of Grove street. There are about three miles of

distributing mains, which are in part 4-inch cast iron, but mostly small galvanized iron pipes.

The Spring.—This is located in low ground about 300 feet from a small river which is known as the North Branch of the Pequabuck River. It is covered with a small wooden building. Being in the village, there are several houses in the vicinity, and two privies with vaults within fifty feet. The water varies in temperature between 48° and 52° F. and is, therefore, probably mostly of deep origin. It was formerly used to supply trout hatching ponds, but is used now only as a water supply for the village.

The Pumps.—There are two pumps located across the river from the spring. They were connected with it by two 2-inch galvanized pipes, which therefore ran across the river. The pipes were connected in the pump-house, so that each pump drew on both pipes. The pumps are operated by water power derived from a dam a short distance up the stream. The water is forced by the pumps through two delivery pipes across the river again into the distributing mains.

The Reservoir.—This is sixty feet long by twenty feet wide and four feet deep, and has stone walls and a hard-pan bottom. It is covered with a tight wooden building. The reservoir is about twenty feet from a cultivated field and a barn yard, both of which are higher than the bottom of the reservoir. There are no other sources of contamination apparent, as the houses in the vicinity are on lower ground.

At the time of my first visit data concerning 27 cases of typhoid fever were furnished me by Doctors Brennan and Kent. The evidence presented in the history of these cases was to the effect that there was no common milk supply for all of them, but that all had used the public water. The suspicion that the water was the means of infection was strengthened by noting the close relationship between the residences of the cases and the course of the water mains, which was clearly seen when both were marked on a map. The importance of discovering and removing the cause of infection was so great that these facts demanded a thorough examination of the water supply without the delay incident to the collection of more complete data. This conclusion was reached and acted upon, although earlier in the day an inspection of the reservoir and source of the water had

been made in the company of Health Officer Brennan and Selectmen Congdon, Manross and Warner, and although I was informed at that time that a sample of the water had been examined in a neighboring city and had been pronounced pure. The sample, the report on which was furnished me by the Selectmen, had been collected from a faucet in the house of Selectman Manross on Center street, near the corner of Garden street, on April 6th, and had been sent away for examination by the acting Health Officer, Dr. Carrington. The following is a copy of the report so far as it relates to the analyses and the opinion based on them. It was dated April 9th, 1900.

"I enclose herewith the result of my sanitary and bacteriological examination of the sample of water you sent April 6, 1900, from the reservoirs of Forestville:

	Parts per Million.
Free Ammonia.....	.0006
Albuminoid Ammonia.....	.0018
Chlorine.....	15.
Nitrogen as Nitrates and Nitrites.....	.000
Bacteria per c. c.....	130.

"Examination in Kashida's medium shows no trace whatever of contamination with any animal matters.

"This sample of water is singularly free from any pollution of any kind, and is perfectly safe to use for drinking. You certainly will have to look for some other source of typhoid infection than this particular water supply."

Under date of April 29th, the author of the report wrote to Dr. H. D. Brennan, commenting on his report as follows:

"I see by this morning's *Globe* that I am quoted as having found a large quantity of chlorine in the sample of water, and that it indicated sewage contamination. By reference to my notes I find that the quantity of chlorine I found was one and fifty-one-hundredths parts per million. This quantity very closely corresponds to the amount to be found in about all the waters in this region, and I am certain does not indicate any contamination with animal matter of any kind."

The evidence above referred to as throwing suspicion on the water was presented to the owner of the water works and he promptly volunteered to make any tests of the system that might be suggested. After another careful inspection of the surroundings it was determined to test the soundness of the pipes connecting the spring and pump-house. And for this purpose the pipes were closed at the spring and one of the pumps started, with the result that a flow of water was obtained. To fix the location of the leak thus indicated, the pump was disconnected and the pressure from the reservoir suddenly turned on.

Immediately there was a discharge of air through the water of the river at a point about 20 feet from the west bank, where the main stream was joined by the flow from the tailrace of a factory above. Examination now showed that one of the two-inch pipes had been broken entirely across, and that the pump end was quite separate from the other piece and hung some little distance above the bottom of the river. After the pipe was removed it was seen that it was somewhat bent about three feet from where it was broken, and that the fracture had occurred at one of the couplings. The nature of the break was such that as the pumps drew on both pipes at once, they must have delivered a mixture of spring water drawn through the sound pipe and of river water taken in through the broken one. Considering the matter of the friction in the two lines it is probable that the river water considerably exceeded the spring water in the mixture. Three samples of water were taken for analysis: one, from the faucet in the pump-house as the water was running back from the distributing pipes into the river, represents the mixed water pumped during the day: one, from the pumps when the spring was cut off, represents the river water as it came through the pumps; and one which was taken directly from the spring with a dipper. These samples were taken by myself between three and four o'clock of the afternoon of April 28th. They were analyzed in the Sanitary Laboratory of the Yale Medical School with the following results:

Analyses of Samples of Water from Forestville.—The spring water was clear, colorless and odorless. The river water was clear, contained a scanty brownish flocculent sediment, was yellowish in color (0.3 of color scale) and was odorless. The pipe water was clear, contained a small brownish flocculent sediment, was yellowish in color (0.2 of the color scale) and was odorless.

In the chemical analyses the following results were obtained expressed in parts per million:

	Spring.	River.	Pipe.
Residue on Evaporation, total at 100° C.	89.0	41.5	66.5
“ “ Volatile on heating in ignitor	10.0	11.0	14.0
Chlorine in combination as Chlorides.....	10.5	3.10	4.70
Nitrogen of Free Ammonia.....	.004	.004	.008
Nitrogen of Albuminoid Ammonia.....	.024	.078	.094
Nitrogen of Nitrites.....	.001	.004	.001
Nitrogen of Nitrates	3.50	.50	1.00
Oxygen Consumed from acid Permanganate 30 m., at 100° C.25	2.85	2.90
Hardness, equivalent to Calcium Carbonate....	37.	15.	20.

In the bacteriological examination the number of bacteria growing in peptone gelatine at the room temperature in seventy-two hours was as follows, expressed in the number per c.e.

Spring, 22 ; River, 297 ; Pipe, 183.

In cultures made in lactose-litmus-agar at a temperature of 38° C. acid-producing growths were obtained in the river and pipe water, but none in the spring water. In order to ascertain whether these acid-producing forms were the colon bacilli, cultures were made from selected colonies, and bacteria were separated from each of the duplicate plates from the river and pipe water, which produced gas when grown in dextrose gelatine ; gave positive results with the indol test ; coagulated milk with the formation of acid, and which on microscopical examination were motile short rods. From these tests it was concluded that the colon bacillus was present in the samples of river and pipe water.

The spring water presents the characteristics commonly found in springs and wells in more or less thickly inhabited sections where the ground water has received a sewage pollution from the drainage of houses, but where the organic matter of the sewage has been largely removed by the process of oxidation as the water has percolated through the ground. That the purification has been quite satisfactory in this case is indicated by the low figures for nitrogen of albuminoid ammonia and for oxygen consumed, which are the data referring especially to the organic matter. That the past contamination had been considerable is shown by the figures for chlorine and nitrates. The normal average chlorine for the region is about 1.8 and the difference between this and 10.5 is to be taken as an index of the amount of past contamination. In percolating through the ground the nitrogen of the organic matter in the contaminating material is oxidized and exists in the purified water in the form of nitrates. The amount of nitrogen of nitrates in this water, 3.50 parts per million, indicates a considerable past contamination. The number of bacteria, 22 per c.e., is less than might have been expected from an open spring situated as this is. The small number of bacteria, the absence of the colon bacillus and the low figures for nitrogen of ammonias are to be taken as evidence of the absence of direct



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MAP OF FORESTVILLE.

Red lines show the situation of the water mains.

Red dots show where cases of typhoid fever occurred. Where more than one case occurred in the same house the fact is indicated by placing other dots behind the first one.

sewage contamination. Concerning the future use of this source of supply, it may be said that a water having these characteristics is necessarily subject to suspicion as one liable under favorable conditions to become the means of infection, as there is no certainty that the purification will be as complete at all times as the above analysis indicates was the case at the time the sample was taken.

The results of the examination of the river water indicate that it was a pretty pure surface water which had received a small sewage contamination, this being seen chiefly in the moderate but distinct increase in the chlorine and in the presence of the colon bacilli. The water drawn from the pipes resembles the river water more than that from the spring, and presents the same evidence of sewage contamination.

The analyses indicate, therefore, that the pipe water contained recent sewage contamination, and that this came from the river water rather than from the spring. As will be shown later, the source of the sewage contamination was such that the contaminating material must have varied considerably from time to time. This fact affords a ready explanation of the presence of more organic matter in the pipe water than in the sample of river water, and also for the absence of a uniform ratio between the chief constituents in the three waters.

The Relation Between the Cases and the Water Supply.—The accompanying map shows the location of the 46 cases occurring in Forestville, and also the course of the distributing water mains. It will be seen at a glance that there were four cases that were not located on the lines of the pipes. Two of these occurred in one house and were probably secondary cases, as the persons were in attendance upon a case which began on April 1st, and as they were taken ill on April 18th and 21st, respectively. The other two, located on Pine street and Swede Row, were men whose places of business were on Broad street, near the corner of Main, where they used the public water supply. Many of the houses on the line of the water mains were not connected and the occupants did not regularly use the public water. Three cases living in houses on streets through which the water mains passed were reported as using only well water at home; two of these, however, drank the public water at their place of business. The remaining case, which occurred on April

23d, used well water, and no information was gained which would permit of an opinion as to how she received the infection. It occurred in a house next to one of the fatal cases and may have been due to secondary infection. Every other case was reported by the physicians in charge as having used the public water supply.

In addition to the 46 cases in Forestville there was one in Bristol and one in Plainville, which as already stated are to be considered as a part of this outbreak. One was the case of a lad of nine, who was visiting from April 12th to 17th, in Forestville, in a house on Washington street, supplied with the public water. He was taken ill in Bristol on May 1st. The other was that of a young girl attending school in Forestville, who had also spent much of her time with relatives at a house on Center street, where she had drunk the public water. She was taken ill on April 1st. Out of the 48 cases, therefore, three only are not known to have used the public water, and two of these are reasonably accounted for as having been secondary cases, and the other may have been such.

These facts are especially significant as fixing the water as the means of infection when it is considered that but 86 tenements were supplied with the water, and that these tenements represent perhaps 400 persons, or about one-quarter of the population of the village.

THE SOURCE OF THE INFECTION.

It has already been shown that the public water supply contained a large admixture of the water of the North Branch of the Pequabuck River, and that the sample of water from this river and from the pipes both showed by their chemical composition, and the presence of the colon bacillus, that they had received sewage contamination. This river has a watershed above this point of about 13 square miles, on which are located a number of farm houses. There are three or four small shops on the upper part of the river employing from one to five hands each. Doubtless some contamination comes from these sources, but it would appear that it must be small. The chief contamination of the river occurs at the factory known as the Burner Factory, situated in Forestville. This place employed during the past spring about 200 hands. All the waste from this fac-

tory passes into the river. The chemicals employed are chiefly such as are used in cleaning brass, as soap, potash, and certain acids, chiefly nitric acid. The acids which are used for dipping the brass naturally dissolve and carry with them a certain amount of copper and zinc. The total amount of acids of all kinds amount to only about a carboy and a half a day. Concerning the effects of these chemicals upon the water, it may be said that the sample of river water analyzed was found to be neutral to litmus, and that none of three samples taken gave any reaction for copper with hydrogen sulphide which could be seen in a layer of water nine inches deep. The contamination of most significance as the possible source of typhoid infection, is of course the excreta from the employees. The factory was well supplied with closets of an excellent design and they were much used. In all there were 26 closets and 6 urinals, which were so placed that their discharge went directly into the stream at a point where the channel was so narrow as to promptly wash the material down stream. This outlet was about 300 feet above the point where the broken pipe was located. The conditions were such that the water pumped must of necessity contain some of the excreta discharged into the river at the factory. Without doubt this was the source of the sewage contamination and of the colon bacilli found in the sample of water analyzed. No information was secured tending to show that there were in the factory any cases of typhoid fever prior to the outbreak in Forestville, although there were ten or twelve of the employees of this factory among those who were ill. The hands employed were shifting more or less, and came from Bristol, Plainville and New Britain, as well as from Forestville, and it was practically impossible to investigate thoroughly this part of the problem. Typhoid fever had existed earlier in the year in both Bristol and Plainville and an undiscovered convalescent or walking case may easily have been among the 200 employees of this factory and have infected the river water.

Time of the Infection.

The outbreak began with four cases, which occurred on March 23d, after which there were but four during the rest of the month. During the first half of April there were 30 cases, which were followed by only 10 cases up to May 2d, when the statistics were gathered. Information has reached me of

three cases occurring since that date. This distribution of cases calls for a period of infection extending from the early part of March well along into April. Of course it is possible that the contagium existed in the water up to April 28th, when the break was discovered and closed, and that the lessened number of cases was due to the precautions taken in using the water, or to the relative immunity of those not already ill.

As to the time when the water pipe was broken, it may be said that this probably occurred at the time of an unusually high flood on the first day of March. There were two other occasions during the winter when the water was high, but at this time it was reported as being higher than the usual spring freshet. This flood was occasioned by an unusually heavy rain when the ground was frozen. The water surrounded the factory and flowed over the region where the spring is located to such an extent as to rise three feet above the level of the spring. A short distance below the point where the pipes crossed the river, and at a bend in the river, were lodged a heavy timber and a trunk of a large tree, which came down at the time of this flood. As the pipes appeared to be strong, and as the one that was broken was bent slightly about three feet from the point of fracture, it seems probable that it was broken by being struck by some heavy object, possibly one of these timbers, at the time of the flood. If so, the water supply began to be contaminated with river water the first day of March, and this contamination continued until the day of its discovery, April 28th. The date thus fixed is twenty-two days before the first cases of typhoid fever appeared, a period entirely consistent with the known period of incubation, when it is considered that for the first few days, owing to the large flow of water due to the flood, the contaminating material must have been very largely diluted.

Conclusions.—The conclusions reached in this investigation are, that the outbreak in Forestville was one of typhoid fever: that there were about 50 cases, and 7 deaths: that the infection was received through the drinking water regularly supplied to about 400 persons: that the water became infected by an addition of river water caused by a break in one of the inlet pipes where it passed through a river: and that the river water was sewage-contaminated by the discharge from the closets of a factory employing about 200 persons, and situated a few rods above the location of the break in the intake pipe.